Sabancı University
Faculty of Engineering and Natural Sciences

CS406/CS531 Parallel Computing / Parallel Processing and Algorithms

Spring 2019-2020

Homework #2

Due: 10/04/2020 - 23:55

PLEASE NOTE:

Your program should be a robust one such that you have to consider all relevant programmer mistakes and extreme cases; you are expected to take actions accordingly!

You HAVE TO write down the code on your own.
You CANNOT HELP any friend while coding.
Plagiarism will not be tolerated!!

1 Introduction

In this assignment, you will parallelize a sequential Futoshiki Solver. The definition of the Futoshiki Puzzle and techniques for solving could be found at futoshiki.org. The purpose of the homework is parallelizing an algorithm for Futoshiki Puzzle while being **as efficient as possible.** Note that the grading will be done based on the end-to-end execution times of implementations.

2 Program Flow

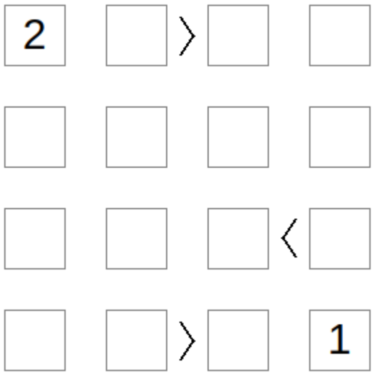
For this homework, you will parallelize the provided implementations which are chosen among the fastest HW1 submissions. There are two alternatives for you to work on; namely *alternative1.cpp* and *alternative2.cpp*. Alternative 2 is faster but it is not ready to work with matrices bigger than 8x8. If you choose this one you need to make work for larger problems. Apart from that, program flow is same as HW1:

- Each input will begin with an integer n that indicates the size of the matrix.
- Each input will contain a square matrix which cells with values presented by positive numbers and empty cells presented with $-\mathbf{1}$'s. The values are separated with whitespaces.
- Each input will have constraints for the puzzle after the matrix. One line for one constraint. Constraints are given in a format that; the value of cell resides in coordinate of first two numbers is bigger than the cell resides in latter two. For example, constraint 1 2 1 3 means that cell at $(1, 2)$ will have bigger value than cell at $(1, 3)$. Therefore an input `input1.txt` will be in the format:

```
4
2  -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1  1
1 2 1 3
3 4 3 3
4 2 4 3
```

will represent the matrix given right.
(Notice 1-based index.)

The input files will be given in correct format and you do not need to implement any input checks.



- The result will be printed out to standard output as a matrix which columns separated with empty space and rows separated with \n.
- For example, solution to the given puzzle should be printed out to matrix as:

```
2 4 1 3
3 1 4 2
1 2 3 4
4 3 2 1
```

3 Solution Calculation

In order to speed the provided implementations up, you will need to parallelize given heuristics. Since the privded puzzles are bigger in this homework, they don't have only one solution, therefore different heuristics could give different results. The important aspects to consider are:

- `Solved()` function could return `True` for found solution.
- Solution could remain same for different thread numbers for same heuristic.

To give a baseline, for *alternative1.cpp*, sequential run times and solutions to inputs are provided.

Input	Size	Sequential Time
input1	9x9	272s
input2	10x10	319s
input3	11x11	90s

Your report will have equal importance as the implementation. A report of at least two pages should be submitted along with the code, including:

- A general explanation of the implementation
- Execution times and speed-ups for $\{1, 2, 4, 8, 16\}$ threads
- Tricks done for efficiency (providing spatial/temporal locality, preprocessing etc.)
- How you compile and run your program.

4 Some Remarks

In the grading process, three things will be checked:

- Correctness of your implementation
- Efficiency of your implementation
- How well the report is written

Your code will be compiled with the **-O3** optimization flag, so you are expected to include the relevant results in your project. You can use the given example matrices and its solution to check the correctness of your code. The solutions of the matrices given for homework will also be provided. **Also, you need to show that your calculation is correct by calling `Solved()` function.**

5 What and Where to Submit (PLEASE READ, IMPORTANT)

Please don't forget to submit your code and the report together. Your **REPORT** must be a **pdf** file (preferable prepared by LaTeX but MS Word converted pdf's are also OK). It must contain the description of the optimizations you implemented, i.e., it must explain how you improved the performance, what was the timings before and after. You must do this for both of the –O0 and –O3 optimization options. Please see above what else do you need to include in the report.

The grading process is not automatic. However, the students are expected to strictly follow the guidelines in order to have a smooth grading process. If you do not follow these guidelines, depending on the severity of the problem created during the grading process, 5 or more penalty points are to be deducted from the grade. The name of your source code file that contains your program must be **futoshiki_hw1.cpp**. Similarly the report must be named as **report_hw1.pdf**.

Put both of these files into a folder named

SUCourseUserName_YourLastname_YourName_HWnumber

Your SUCourse user name is actually your SUNet username that is used for checking sabanciuniv e- mails. Do NOT use any spaces, non-ASCII and Turkish characters in the file name. For example, if your SUCourse user name is cago, name is Çağlayan, and last name is Özbugsızkodyazaroğlu, then the folder name must be:

cago_Caglayan_Ozbugsizkodyazaroglu_hw1

Do not add any other character or phrase to the folder name. Make sure that it contains the last version of the source code and the report. Compress this folder using a zip program. Please use "zip" compression. **"rar" or another compression mechanism is NOT allowed. Please make sure that you include both of the files in the compressed folder.**

You will receive no credits if your compressed folder does not expand or it does not contain the correct files. The name of the zip file should be as follows:

SUCourseUserName_YourLastname_YourName_HWnumber.zip

For example zubzipler_Zipleroglu_Zubeyir_hw1.zip is a valid name, but

hw1_hoz_HasanOz.zip, HasanOzHoz.zip

are **NOT** valid names. **Submit via SUCourse ONLY!** You will receive no credits if you submit by other means (e-mail, paper, etc.).

Successful submission is one of the requirements of the homework. If, for some reason, you cannot successfully submit your homework and we cannot grade it, your grade will be 0.

Good Luck!

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